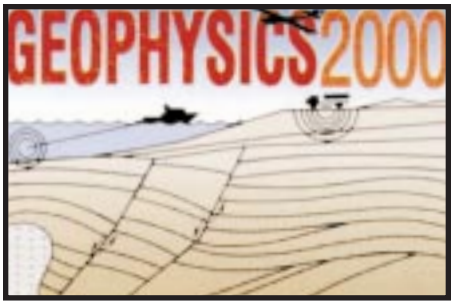
Microseeps to Get MIDAS Touch

This is thinking small – Broadly

By KATHY SHIRLEY
EXPLORER Correspondent



In the past, field-scale measurement techniques for direct detection of hydrocarbon seeps over land have not been available.

An old way of finding oil is still proving to be a valuable way of finding oil—and teams of scientists are hopeful that the MIDAS touch will once again prove golden.

No, not that Midas.

This MIDAS refers to Microseep Identification by Direct Atmospheric Spectroscopy.

Hunting for oil by first locating oil seeps has become an increasingly sophisticated exploration approach, and a proposed project between the non-profit Geosat Committee Inc. and Chimera Geophysical Corp. would test one of the latest advancements in microseep detection.

Last year Geosat completed its "hyperspectral group shoot," an industry-sponsored project designed to evaluate hyperspectral airborne scanners for seep detection both offshore and on land. The success of that cooperative research project encouraged Geosat to partner with Chimera to evaluate the new remote sensing tool through Project MIDAS.

Project MIDAS is based on the idea that hydrocarbon microseeps exist over some oil and gas reservoirs and are expressed by hydrocarbon concentration anomalies in the atmosphere above the microseeps.

(Chimera operates the new instrument that provides atmospheric concentration measurements of hydrocarbons.)

Cue musician Phil Collins: *"I can feel it coming in the air tonight ..."*

"Oil finds have long been associated with macroseeps, and the concept behind this instrument is that there are also seeps at much lower levels—microseeps—that can't be easily detected without sophisticated, sensitive equipment," said Paula Wamsley, an optical physicist with the Ophir Corp., which initially developed the technology.

"From an exploration standpoint," she added, "a tool that can locate very small hydrocarbon gas anomalies in the atmosphere would be an additional tool with which to high grade prospects."

The instrument is a mobile, mid-infrared, differential absorption lidar (DIAL) system for the detection of low molecular weight hydrocarbons in the atmosphere.

The system employs a laser system recently developed and patented by Ophir—the laser is a Raman shifted Cr:LiSAF laser operated in a master oscillator/power amplifier configuration. In order to produce a much smaller spectral bandwidth, a spectroscopic grade laser source is produced by injection, seeding the Cr:LiSAF oscillator with a continuous wave diode laser.

The eye-safe laser pulses emitted by the system are returned to a trailer that houses the system by a retroreflector, which can be placed a mile or more away, she said.

The long path measurement is one channel of a three-channel system. The other two channels are a pulse energy normalization channel and a reference cell channel, which includes a cell that contains calibrated hydrocarbon gas mixtures.

The reference channel also allows operators to validate spectral performance of the system with each laser pulse, helping to ensure that the system is detecting hydrocarbons and not other gases in the atmosphere.

Auxiliary systems include a weather station and global positioning system receivers.

Developments in near surface exploration technology have generally focused on point-scale measurements or large-scale, satellite-based measurements and techniques to fuse the two types of data into advanced exploration tools, Wamsley said.

However, for exploration purposes, point-scale measurements are costly because many points have to be sampled and large-scale measurements may not have the spatial resolution to capture an anomaly produced by a field-scale reservoir.

Direct Detection

The idea of using remote sensing techniques for the detection of hydrocarbon microseeps is not new. For example, a patent was issued in 1972 for use of an indirect microwave technique for the remote sensing of hydrocarbon microseeps in the atmosphere.

The new instrument for MIDAS is based on the premise that gases from pressurized, subsurface reservoirs leak through imperfect seals into the atmosphere at rates detectable through *direct* measurement of individual hydrocarbon concentrations in the atmosphere.

"The DIAL system is capable of detecting trace concentrations of light hydrocarbons along a one-mile path through the ambient atmosphere," Wamsley said.

"The minimum detectable concentration is a function of the specific gas, distance sampled and weather conditions, but is better than a tenth of a part per million for methane, ethane and propane."

For comparison, the concentration of methane in unpolluted air is approximately 1.8 parts per million, and that of ethane is just 0.006 parts per million.

Ophir, which focuses on research and development for atmospheric sciences and instrumentation, began work on the DIAL system in 1992 when the Department of Energy's Small Business Innovation Research program solicited work for new sensor concepts to detect leaks in natural gas pipelines from an airborne platform,

said Carl Weimer, Ophir's director of research and lead scientist.

The firm was also awarded a contract with the U.S. Air Force to further develop the technology for Air Force applications.

After the laser was demonstrated in the laboratory, the technology was licensed to a Midland, Texas-based oil company for use in oil and gas exploration, he said. Laser Exploration Inc. funded development of a field prototype, which was delivered in 1998, and field-tested the system in Texas and Colorado.

The system performed well in temperatures from 45 to 100 degrees, relative humidities near 100 percent and high winds. It also maintained sub-parts per million detection sensitivities for methane, ethane and propane, even after the shock and vibration of both highway and field transport.

"We envision that the DIAL system can be used as a survey tool to explore large areas for microseeps," Wamsley said. "Once microseeps are detected, more costly exploration tools such as 3-D seismic would be applied to the most promising survey areas.

"An important aspect is that the exploration technique is a direct detection method in that the DIAL system directly detects the natural resource of interest," she added. "This is in contrast to many other geochemical or spectral techniques (e.g., hyperspectral imaging) in which the measurements represent indirect evidence of a subsurface accumulation."

Performance Objectives

Several key performance objectives have been identified for the system, including:

- ✓ Good spectral purity – required to obtain accurate concentration measurements.
- ✓ Sufficient pulse energy – necessary to provide adequate signal levels at operating distances of up to and over one mile.
- ✓ Optical alignment stability.
- ✓ Real-time measurements.
- ✓ Reliability.
- ✓ Mobility.
- ✓ Ease of operation.

In field studies the goal of sufficient pulse energy was routinely achieved, Wamsley said—largely an indication that the laser optical alignment has good stability. In order to hit the 20-inch diameter retroreflector at a distance of one mile, the transmitting optics must have good stability—and this goal was also achieved in gusty wind conditions during the field tests.

Testing thus far has shown the system to be reliable. No components failed or were damaged during the seven-day field tests.

Mobility and ease of operation are critical to making the technique cost effective. Crews were able to rapidly reposition the retroreflector, and the trailer and the optical alignment showed a high level of stability after each repositioning with only minimal adjustments needed to resume data acquisition.

Proving Grounds

The successful field tests prompted Chimera Geophysical (an independent company that contracts with Ophir) and Laser Exploration to pursue a more in-depth field study in conjunction with Geosat.

"This technology provides new remote sensing capabilities," said Rebecca Dodge with Geosat.

"Details of how best to operate the system and interpret the data for exploration applications are still being determined," she said. "This cooperative research project would look at how systematic measurements are carried out in order to optimize the system for oil and gas exploration."

Each study will be conducted at a well characterized, geologically unique site. They are designed to:

❒ Provide concentration data, which will be a first of its kind collection of the magnitude of hydrocarbon concentrations over a variety of reservoirs.

❒ Establish measurement procedures that optimize the advantages of the new field-scale measurement capability.

The ultimate goal is to use this information to identify signatures of economically valuable hydrocarbon reservoirs.

Chimera and the Geosat Committee are seeking industrial, government and academic partners to supply funding and geoscience expertise for the MIDAS project. Geosat will administer the project, Laser Exploration will provide the instrument and Chimera will conduct the research, including coordination and collaboration with participating partner scientists.

Final test sites, research objectives, project duration and deliverables will be negotiated with project participants.

"Geosat has conducted several cooperative research projects, or 'group shoots' like this in the last decade," Dodge said. "Industry participants help define the test sites, and can then quickly see and use the results of a large applied research effort, but only pay a small part of the total cost.

"The technical goal is to use controlled field studies to further define sensitivity requirements and temporal and spatial requirements on the measurement grid for field-scale exploration applications," Wamsley said. "With this information, a more thorough evaluation of the DIAL remote sensing technique for hydrocarbon exploration will be possible."

Questions to Consider

Technical questions have already been identified that scientists will address in more extensive field studies. These include:

How large are atmospheric concentration anomalies above the reservoir?

Are there spatial or temporal gradients in the atmospheric concentrations above the reservoir?

To what extent are spatial and temporal gradients in the atmospheric concentration the result of emission inhomogeneities rather than surface mixing mechanisms?

To what extent can spatial gradients in the atmospheric concentration be correlated with geophysical surface and subsurface features?

How efficiently can small-scale surface emission "hot spots" be located?

To what extent are the relative atmospheric concentrations of the various hydrocarbons indicative of reservoir composition?

At what level can local surface emissions be distinguished from polluted air that has been transported to the reservoir site?

What is the impact of local and regional weather on reservoir anomalies?

What is the impact of vegetation on reservoir anomalies?

"The goal of the MIDAS Project is to detect and locate hydrocarbon microseeps in the atmosphere, whether they are natural or man-made," Dodge said. "MIDAS complements other exploration techniques by incorporating the use of a new instrument with field-scale measurement capability."

MIDAS may also find application in the development of coalbed methane

fields and enhanced oil recovery operations where it can be used to locate areas with the highest rate of vertical migration, Dodge said.

"Finally, we anticipate the MIDAS will be useful for detecting seepage of natural gas from underground gas storage reservoirs into the atmosphere," she added.

"The long path monitoring capability of the system may also be the solution to complex environmental monitoring situations such as the monitoring of petroleum processing plants for above ground and below ground leaks."

Looking Up

Today the DIAL system is configured for land-based operation, but the developers would like to transfer the system to an airborne platform.

The laser incorporated in the DIAL system is adequate for airborne operation. It is rugged, has high wavelength resolution, is wavelength tunable and has high pulse power.

Dodge said that "this new technique is just the kind of project the Geosat Committee looks for—we establish cooperative research projects to test new technologies in remote sensing that are not yet commercial, but which can become important new tools through applied research done in cooperation with end users."

Geosat's hope, she said, is "to bring together a group of end users, government and academic scientists, and the developers of this DIAL system to conduct applied research and determine the new technology's value for hydrocarbon exploration, as well as other petroleum industry applications." ❑

Who is the AAPG

The American Association of Petroleum Geologists

P.O. Box 979
Tulsa, Oklahoma
74101-0979
USA

Offices:
1444 South Boulder Avenue
Tulsa, Oklahoma
74119

E-mail: info@aapg.org

Web address:
http://www.aapg.org/

Phone
(USA and Canada):
1-800-364-2274
Information Center
1-888-945-2274
Staff Directory

(Other Locations)
1-918-584-2555

Fax
(USA and Canada):
1-800-898-2274

(Other Locations)
1-918-560-2665

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